

SONGS OF *AIMOPHILA* SPARROWS OCCURRING IN THE UNITED STATES

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SIX species of *Aimophila* occur in the United States, one in the East and the other five in the Southwest:

1. Bachman's Sparrow (*A. aestivalis*) breeds from Maryland to Missouri and south to Florida and eastern Texas; generally occurs in abandoned fields with scattered trees and shrubs.

2. Rufous-winged Sparrow (*A. carpalis*) breeds in desert areas in south-central Arizona.

3. Botteri's Sparrow (*A. botterii*) breeds in grassy areas in the Brownsville region of Texas and in southeastern Arizona.

4. Cassin's Sparrow (*A. cassinii*) breeds in arid grasslands from western Kansas to southern Texas and southeastern Arizona.

5. Rufous-crowned Sparrow (*A. ruficeps*) breeds in southwestern United States, and generally occurs on slopes between 3,000 and 6,000 feet elevation.

6. Five-striped Sparrow (*A. quinquistriata*) breeds in brushy, semi-desert slopes in Mexico; with recent records in south-central Arizona.

Bachman's, Cassin's, and Botteri's Sparrows are plain-colored and similar in appearance; Rufous-crowned and Rufous-winged Sparrows are not conspicuously marked but are relatively easy to identify by sight; the Five-striped Sparrow is distinctive in appearance, and readily distinguished from the other U. S. species of *Aimophila*. Rufous-crowned, Cassin's, and Botteri's Sparrows may occur together in south-central Arizona; Bachman's is eastern, and its breeding range does not overlap that of any other U. S. *Aimophila*; The Rufous-winged and Five-striped Sparrows probably do not occur with any other species of *Aimophila* (at least in the U. S.), though I have found Cassin's and Rufous-winged Sparrows only a few miles apart in south-central Arizona.

Brief descriptions of the songs of all these sparrows except the Five-striped are given in various guides, with somewhat more complete accounts of their songs in U. S. National Museum Bulletin, No. 237. I know of no detailed study of *Aimophila* songs based on audiospectrographic analyses of tape recordings (except Bachman's: Borrer, 1961*a*, 1961*b*, and 1970); the only published sonagrams of *Aimophila* songs that I have seen are of Bachman's Sparrow by Borrer (1961*b*, Fig. 14, and 1970, Fig. 53), and one song each of the Rufous-crowned, Cassin's, and Bachman's Sparrows by Robbins et al. (1966:316).

TABLE 1
SUMMARY OF *AIMOPHILA* RECORDINGS STUDIED

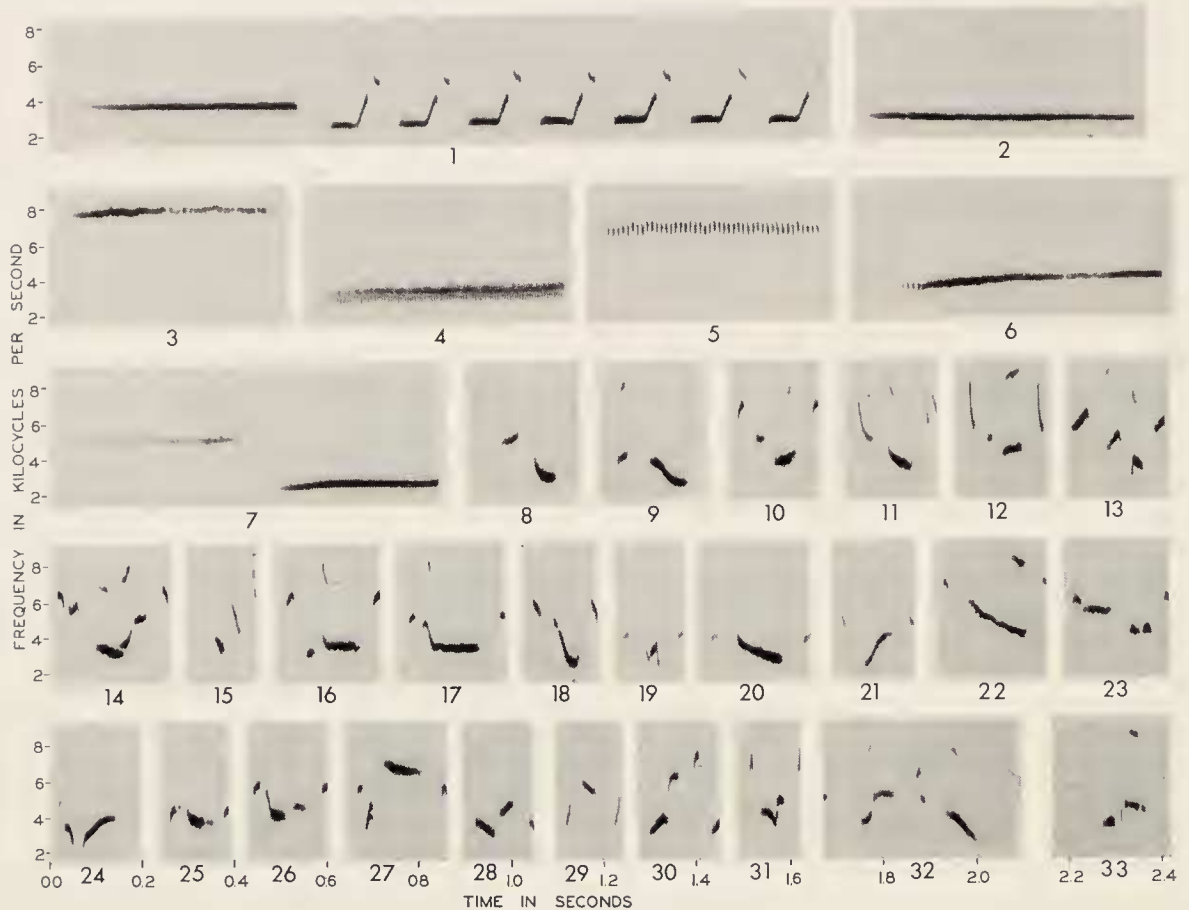
| Species | Where Recorded | Number of Birds | Number of Recordings | Total Songs |
|------------------------|---------------------|-----------------|----------------------|-------------|
| Bachman's Sparrow | Ohio | 4 | 8 | 551 |
| | Florida | 9 | 11 | 280 |
| Rufous-winged Sparrow | Arizona | 6 | 10 | 416 |
| Botteri's Sparrow | Arizona | 1 | 1 | 20 |
| | Mexico ¹ | 3 | 3 | 63 |
| Cassin's Sparrow | Texas | 12 | 14 | 163 |
| | Arizona | 11 | 12 | 100 |
| Rufous-crowned Sparrow | Arizona | 6 | 6 | 63 |
| Five-striped Sparrow | Arizona | 1 | 1 | 113 |
| TOTAL | | 53 | 66 | 1,769 |

¹ Recordings borrowed from the Laboratory of Ornithology, Cornell University.

This paper is based on a study of 66 recordings—63 made by me and in the collection of recorded animal sounds of the Faculty of Zoology, Ohio State University, and three borrowed from the Laboratory of Ornithology, Cornell University (recordings made by L. Irby Davis). These recordings are summarized in Table 1. The graphs were made with a Kay Electric Co. Vibralyzer, using the wide band filter; the source of each graph is indicated in the figure captions by a hyphenated number: the number preceding the hyphen is the number of the recording, and the number following the hyphen is the song in the recording.

BACHMAN'S SPARROW

The songs of this species generally consist of two parts, an introduction of one or two relatively long notes that are steady in pitch or nearly so, and a trill (a rapid series of similar phrases). The trill phrases are usually all alike (rarely the first or last is incomplete), but in some songs the trill is 2-parted (a series of phrases of one type, then a series of another type; see Figs. 32–33). Occasionally the song is double: a long note, a trill, another long note, and another trill. The most common type of song in this species is one consisting of a clear whistled note followed by a trill (*WT* in Table 2: Fig. 1). The songs illustrated by Borrer (1961*b*, Fig. 14, and 1970, Fig. 53) are fairly typical songs of this species; that illustrated by Robbins et al. (1966:316) is rather atypical (double, with each trill 2-parted; the intro-



FIGS. 1-33. Graphs of Bachman's Sparrow songs. Fig. 1, a typical song (8487-5). Figs. 2-7, different introductions: Fig. 2, a low-pitched *W* note (1419-9); Fig. 3, a high-pitched *W* note (1419-14); Fig. 4, a low-pitched *Z* note (1419-31); Fig. 5, a high-pitched *Z* note (1419-5); Fig. 6, a *w* note (1419-27); Fig. 7, a *WW* introduction (1419-30). Figs. 8-31, individual trill phrases: Fig. 8, 3139-5; Fig. 9, 3139-4; Fig. 10, 3139-25; Fig. 11, 4478-28; Fig. 12, 4979-13; Fig. 13, 4478-24; Fig. 14, 4478-5; Fig. 15, 4489-26; Fig. 16, 4478-9; Fig. 17, 4489-15; Fig. 18, 4478-3; Fig. 19, 3782-13; Fig. 20, 3782-11; Fig. 21, 3782-9; Fig. 22, 3782-5; Fig. 23, 1419-2; Fig. 24, 1031-5; Fig. 25, 8487-1; Fig. 26, 1033-3; Fig. 27, 1033-9; Fig. 28, 8487-16; Fig. 29, 1419-15; Fig. 30, 8487-27; Fig. 31, 1033-12. Figs. 32-33, the middle of a two-parted (*TT*) trill, showing the last trill phrase of the first type and the first one of the second type: Fig. 32, 4444-42; Fig. 33, 1419-28.

ductory note for the second part was apparently quite weak, and does not show in the graph). Descriptions of the songs of this species are given by Borror (1961*b*, 1970) and Weston (1968).

The different types of introductions found in the songs studied were as follows (see Table 2):

- : no introduction (in only 2 of the songs studied)
- W*: a whistled note (Figs. 1-3)
- w*: a note similar to *W* but beginning with a buzz (Fig. 6)
- Z*: a buzzy note (Figs. 4-5)

TABLE 2
SONG TYPES IN BACHMAN'S SPARROW

| Song Type ¹ | Ohio | | | Florida | | | All Birds | | |
|------------------------|-----------------|--------------|------------|-----------------|--------------|------------|-----------------|--------------|------------|
| | No. of Patterns | No. of Songs | % of Songs | No. of Patterns | No. of Songs | % of Songs | No. of Patterns | No. of Songs | % of Songs |
| -T | 1 | 1 | 0.2 | 1 | 1 | 0.4 | 2 | 2 | 0.2 |
| WT | 40 | 279 | 51.7 | 103 | 183 | 65.4 | 143 | 462 | 56.3 |
| ZT | 12 | 84 | 15.6 | 30 | 57 | 20.4 | 42 | 141 | 17.2 |
| wT | 4 | 13 | 2.4 | 9 | 19 | 6.8 | 13 | 32 | 3.9 |
| -TT | - | - | - | 1 | 2 | 0.7 | 1 | 2 | 0.2 |
| WTT | 2 | 5 | 0.9 | 9 | 14 | 5.0 | 11 | 19 | 2.3 |
| WTTWT | 1 | 3 | 0.6 | - | - | - | 1 | 3 | 0.4 |
| WTTWTT | 1 | 8 | 1.5 | - | - | - | 1 | 8 | 1.0 |
| ZTT | 1 | 1 | 0.2 | 2 | 2 | 0.7 | 3 | 3 | 0.4 |
| WWT | 11 | 84 | 15.6 | - | - | - | 11 | 84 | 10.2 |
| WWTT | 4 | 25 | 4.6 | - | - | - | 4 | 25 | 3.1 |
| ZWT | 6 | 21 | 3.9 | - | - | - | 6 | 21 | 2.6 |
| WTWT | - | - | - | 1 | 1 | 0.4 | 1 | 1 | 0.1 |
| WTZT | 3 | 9 | 1.7 | - | - | - | 3 | 9 | 1.1 |
| WTWZT | 1 | 7 | 1.3 | - | - | - | 1 | 7 | 0.9 |
| ZTWT | - | - | - | 1 | 1 | 0.4 | 1 | 1 | 0.1 |
| Total ² | 87 | 540 | | 157 | 280 | | 244 | 820 | |

¹ T, a single trill; TT, a 2-parted trill; other letters are explained in the text.

² The total number of *different* patterns, taking into account instances of a given pattern being sung by more than one bird; these totals do not include the 11 songs (five patterns) of one bird that mimicked Field Sparrow songs.

WW: two whistled notes (Fig. 7), found only in songs of Ohio birds; the first W was higher pitched in 7 of the 15 song patterns that began with WW, the second W was higher pitched in 7 patterns, and in 1 pattern the two W notes were the same pitch

ZW: a buzzy note and a whistled note, found only in songs of Ohio birds; the buzzy note was always higher pitched than the whistle.

The trill phrases vary greatly (Figs. 8-33), both in the songs of a given bird and in the songs of different birds. Most of the notes in these phrases are abruptly slurred, sometimes over a considerable pitch range. Phrases of a given type in different songs vary in number but only very slightly in rate; phrases of different types vary (in different songs) in both rate and number.

Each bird has a repertoire of a number of different introductions and trills, but a given trill is almost always preceded by the same type (and pitch) of introduction—producing a particular *song pattern*. A bird usually sings songs of a given pattern 1 to 4 times, then changes to another pattern. Most

TABLE 3
CHARACTERISTICS OF BACHMAN'S SPARROW SONGS

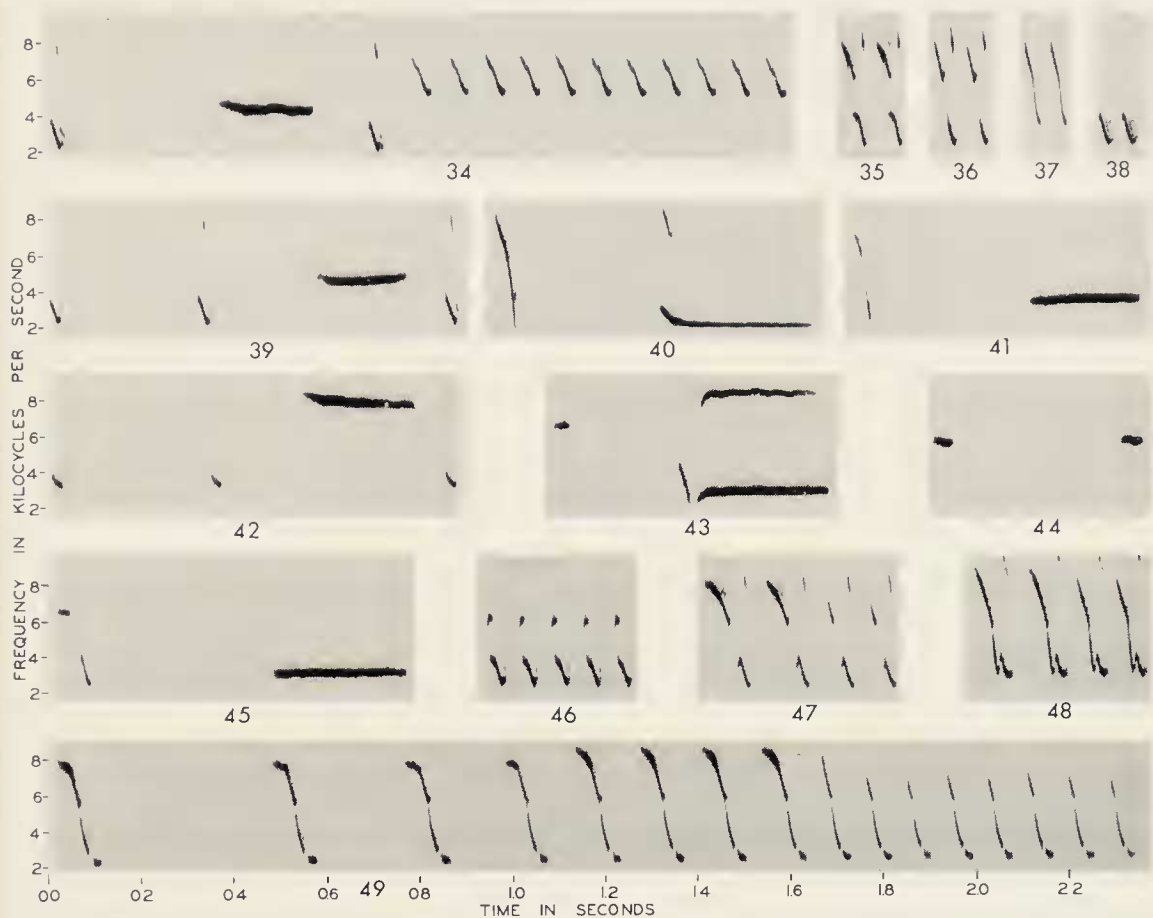
| Character | | Ohio | | Florida | | All Birds | |
|---|----------|-----------|---------|-----------|---------|-----------|---------|
| | | Range | Average | Range | Average | Range | Average |
| Pitch (KHz) | <i>W</i> | 1.8-10.8 | 4.43 | 1.8-8.5 | 4.69 | 1.8-10.8 | 4.54 |
| | <i>Z</i> | 2.3-8.5 | 5.15 | 2.6-8.7 | 5.38 | 2.3-8.7 | 5.26 |
| | <i>w</i> | 3.6-7.0 | 4.78 | 3.2-5.0 | 3.94 | 3.2-7.0 | 4.15 |
| Length (sec.) | <i>W</i> | 0.13-0.70 | 0.45 | 0.17-0.75 | 0.55 | 0.13-0.75 | 0.49 |
| | <i>Z</i> | 0.15-0.82 | 0.50 | 0.42-0.73 | 0.56 | 0.15-0.82 | 0.53 |
| | <i>w</i> | 0.52-0.78 | 0.67 | 0.44-0.72 | 0.61 | 0.44-0.78 | 0.63 |
| Modulation rate of | <i>Z</i> | 44-224 | 174.0 | 90-213 | 165.3 | 41-224 | 168.7 |
| <i>T</i> phrase length (sec.) | | 0.03-0.22 | 0.13 | 0.04-0.27 | 0.16 | 0.03-0.27 | 0.15 |
| No. of <i>T</i> phrases | | 1-20 | 8.9 | 2-15 | 8.8 | 1-20 | 8.8 |
| No. of notes in the <i>T</i> phrases | | 1-4 | 2.2 | 1-6 | 2.8 | 1-6 | 2.6 |

of the birds studied had 20 or more song patterns; the largest repertoire found in an Ohio bird was 36 song patterns, and the largest in a Florida bird was 39 song patterns. Several instances were found in both the Florida and Ohio birds of different birds singing songs of the same pattern, but no pattern was sung by both an Ohio and a Florida bird. A total of 244 different song patterns were found in the recordings studied—87 in the Ohio recordings and 157 in the Florida recordings. There is evidently a tremendous amount of variation in Bachman's Sparrow songs, most of it being in the trill phrases.

Table 2 compares the *types* of song patterns sung by Ohio and Florida birds. Fewer types (but more different patterns) were sung by Florida than by Ohio birds. Much of the variation in the Ohio birds was found in the songs of one bird, some of whose songs were recorded after playbacks of its songs to it. None of the Florida songs contained a 2-note introduction (*WW* or *ZW*), and only 2 of the 280 Florida songs were double (*WTWT* and *ZTWT*). About three-fourths of the Bachman's Sparrow songs studied consisted of a single introductory note and a trill (*WT*, *wT*, and *ZT*).

The 26 songs recorded from one Ohio bird included 11 (of five different patterns) that were imitations of Field Sparrow (*Spizella pusilla*) songs. No playbacks were used when this recording was made.

Table 3 contains data on the characteristics of the songs of Ohio and Florida birds. The pitch range of the *W* notes, which represents the pitch



FIGS. 34-49. Graphs of Rufous-winged Sparrow songs. Fig. 34, a song of Type II (9716-2). Figs. 35-38, parts of trills: Fig. 35, 10151-47; Fig. 36, 10215-6; Fig. 37, 10143-18; Fig. 38, 10151-70. Figs. 39-45, introductions of Type II songs: Fig. 39, 9716-27; Fig. 40, 10215-4; Fig. 41, 10282-130; Fig. 42, 10143-18; Fig. 43, 10151-68; Fig. 44, 10151-47; Fig. 45, 10143-26. Figs. 46-48, portions of Type I songs: Fig. 46, 9732-1; Fig. 47, 10143-3; Fig. 48, 10151-1. Fig. 49, a song of Type I (10143-8).

range in the songs, was from 1.8 to 10.8 KHz; introductory notes over about 6 KHz were usually quite weak, and audible only if the bird was fairly close. Songs with two introductory notes (*WW* and *ZW*) nearly always had the second note shorter than the first. The principal difference between the songs of Ohio and Florida birds was in the character of the trill; the trill phrases of the Florida birds averaged 0.16 sec. in length (about six per second), while those of the Ohio birds averaged 0.13 sec. (about eight per second).

RUFOUS-WINGED SPARROW

Songs of the Rufous-winged Sparrow are of two general types: Type I (Fig. 49), an accelerating series of similar notes or phrases (a little like the songs of a Field Sparrow), and Type II (Fig. 34), songs resembling those of an eastern Rufous-sided Towhee (*Pipilo erythrophthalmus*), and consisting

TABLE 4
DATA ON RUFIOUS-WINGED SPARROW SONGS

| Character | Bird | | | | | | All Birds | | |
|------------------|-------------------------|-------|------|------|------|-------|--------------|------|-----------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| Type I Songs | No. of Songs | | 0 | 0 | 5 | 49 | 54 | 1 | 109 |
| | No. of Trill | Range | — | — | 9-18 | 6-21 | 1-16 | 19 | 1-21 |
| | Phrases | Aver. | — | — | 14.6 | 16.0 | 10.9 | 19.0 | 13.0 |
| | No. of Song Patterns | | 0 | 0 | 1 | 6 | 8 | 1 | 10 ¹ |
| Type II Songs | No. of Songs | | 8 | 29 | 17 | 113 | 140 | 0 | 307 |
| | No. of Trill | Range | 2-13 | 6-13 | 0-17 | 12-25 | 0-17 | — | 0-25 |
| | Phrases | Aver. | 10.6 | 10.9 | 11.9 | 17.6 | 14.1 | — | 14.1 |
| | No. of Song Patterns | | 3 | 2 | 3 | 12 | 11 | — | 24 ¹ |
| All Songs | No. of Songs | | 8 | 29 | 22 | 162 | 194 | 1 | 416 |
| | No. of Song Patterns | | 3 | 2 | 4 | 18 | 19 | 1 | 34 ¹ |

¹ These figures have been corrected for instances of a given song pattern being sung by more than one bird, and represent the number of *different* patterns in the songs studied.

of an introduction of 2 to 4 notes followed by a trill. A bird may sing songs of both types. An account of the songs of this species is given by Phillips (1968).

Type I songs consist of abrupt down-slurs, beginning at the rate of about 1½ per second and ending at the rate of about 11 per second. The song may contain up to 21 phrases (see Table 4), with the last few usually uttered at a constant rate and often slightly different from the first phrases (Figs. 47-49). Some Type I songs are short (up to a half a dozen or so phrases), with the phrases alike and the tempo increasing through the series.

The introduction in Type II songs contains from one to four notes; one of these is often a long note (about ¼ second in length) that is steady in pitch or very slightly down-slurred (Figs. 34, 39-43, 45), and the others (or, in some cases, all the notes of the introduction) are very short and either abruptly down-slurred (like the short notes in Fig. 39) or steady in pitch (Fig. 44). The trill consists of abrupt down-slurs, often slurred over about an octave; sometimes these are a single slur (Figs. 37, 49), sometimes they are 2-parted slurs (Figs. 35-36), and sometimes there is a short low note (Fig. 49) or slurs (Fig. 48) at the end.

The trill phrases in the Type II songs studied varied in number up to 25 (see Table 4); rarely, the trill was absent. The number varied in different songs of the same pattern sung by a given bird. The rate was uniform or nearly so through the trill, and varied (in different trills) from about 8 to 20 (13–15 in most songs) per second. The long steady note in the introduction was sometimes quite high-pitched (Fig. 42); such a high note was often weak, and not audible unless the bird was fairly close.

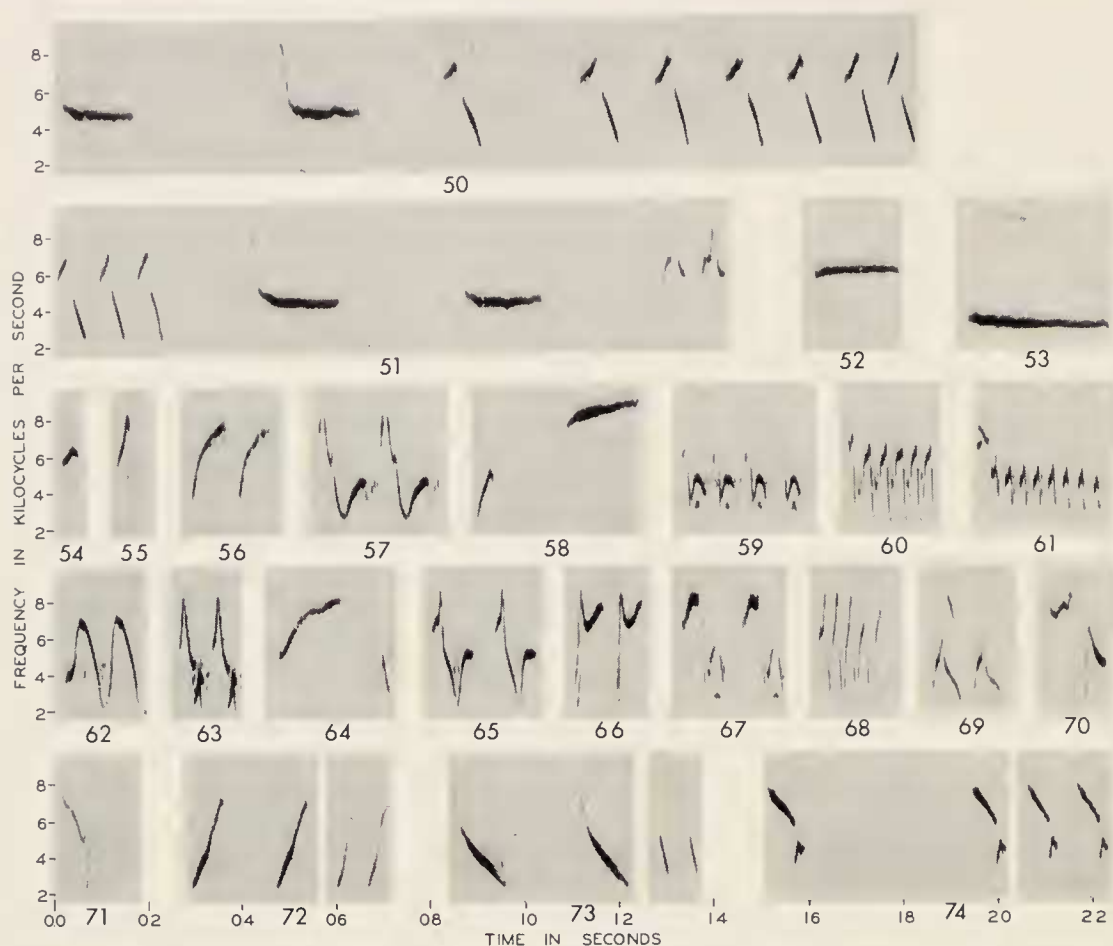
Most of the songs studied had a pitch range of about two octaves (2–8 KHz); the extremes found were 1.8 and 10 KHz. The final phrases in most Type I songs appeared a little lower pitched than the first phrases, due to the dropping out of some of the higher frequencies (Figs. 47–49). The highest pitch in most Type II songs was in the trill, except in some songs having a high pitched note in the introduction (as in Fig. 42).

Each bird apparently has a repertoire of several different introductions and trill phrases, which are variously combined to produce a number of different song patterns; the most found in one bird was 19. The songs of different individuals were often similar or identical; of the 34 different song patterns found in the songs studied, two were sung by three birds, 10 by two birds, and the rest by only one bird. Birds 4 and 5 (Table 4) had territories about a mile apart; 11 song patterns were sung by both birds.

A Rufous-winged Sparrow generally sings songs of one pattern for a while and then changes to another pattern. Some patterns of a given bird are very similar, and may not be recognized in the field as different unless one is heard immediately after the other—an uncommon event, as when a bird changes song patterns it usually changes to one noticeably different from the last.

BOTTERI'S SPARROW

The song of this species consists of up to seven short notes or phrases, followed by a trill that increases in tempo in about the middle, usually followed by one or two 1- or 2-note phrases (Figs. 50–51). The phrases preceding the trill are uttered slowly (about 2 per second), giving the impression that the bird takes a little time to work up to the more rapid tempo of the trill; this impression is enhanced by the fact that the bird often utters isolated phrases (similar to the introductory phrases) between songs. The song is similar to Type I songs of the Rufous-winged Sparrow, with some extra phrases at the beginning and end. Some notes (e.g., Figs. 52–53) are relatively steady in pitch, but most (Figs. 54–74) are rather abruptly slurred. The extremes in pitch found were 1.4 and 12.2 KHz; the pitch of most songs was between 2 and 8 KHz. An account of the songs of this species is given by Monson (1968).



FIGS. 50-74. Graphs of Botteri's Sparrow songs. Figs. 50-51, a complete song (9751-7), with 10 trill phrases; Fig. 51 begins where Fig. 50 ends. Figs. 52-53, notes occurring after the trill: Fig. 52, Cornell-1-7; Fig. 53, 9751-15. Figs. 54-71, Notes and phrases occurring in the introductory part of the song, preceding the trill: Fig. 54, Cornell-3-25; Fig. 55, Cornell-3-22; Figs. 56-57, Cornell-3-25; Fig. 58, Cornell-3-19; Figs. 59-61, Cornell-3-25; Fig. 62, Cornell-3-19; Fig. 63, Cornell-3-2; Figs. 64-66, Cornell-1-5; Figs. 67-68, Cornell-2-2; Figs. 69-71, 9751-15. Figs. 72-74, the first two (left) and last two (right) trill phrases: Fig. 72, 9751-15; Fig. 73, Cornell-3-22; Fig. 74, Cornell-2-7.

Songs of a given song pattern contain particular introductory phrases (usually uttered in the same sequence), a particular type of trill phrase, and particular terminal phrases. The songs of a given pattern may vary in length, due to variations in the number of introductory and/or trill phrases, or to just where along this sequence the song ends (some songs end before the trill). Different song patterns generally contain different phrases.

Two of the recordings studied contained songs of a single pattern, and the other two recordings contained two patterns each. In the recordings with two patterns, the birds sang songs of one pattern for a while, then changed to the other pattern.

CASSIN'S SPARROW

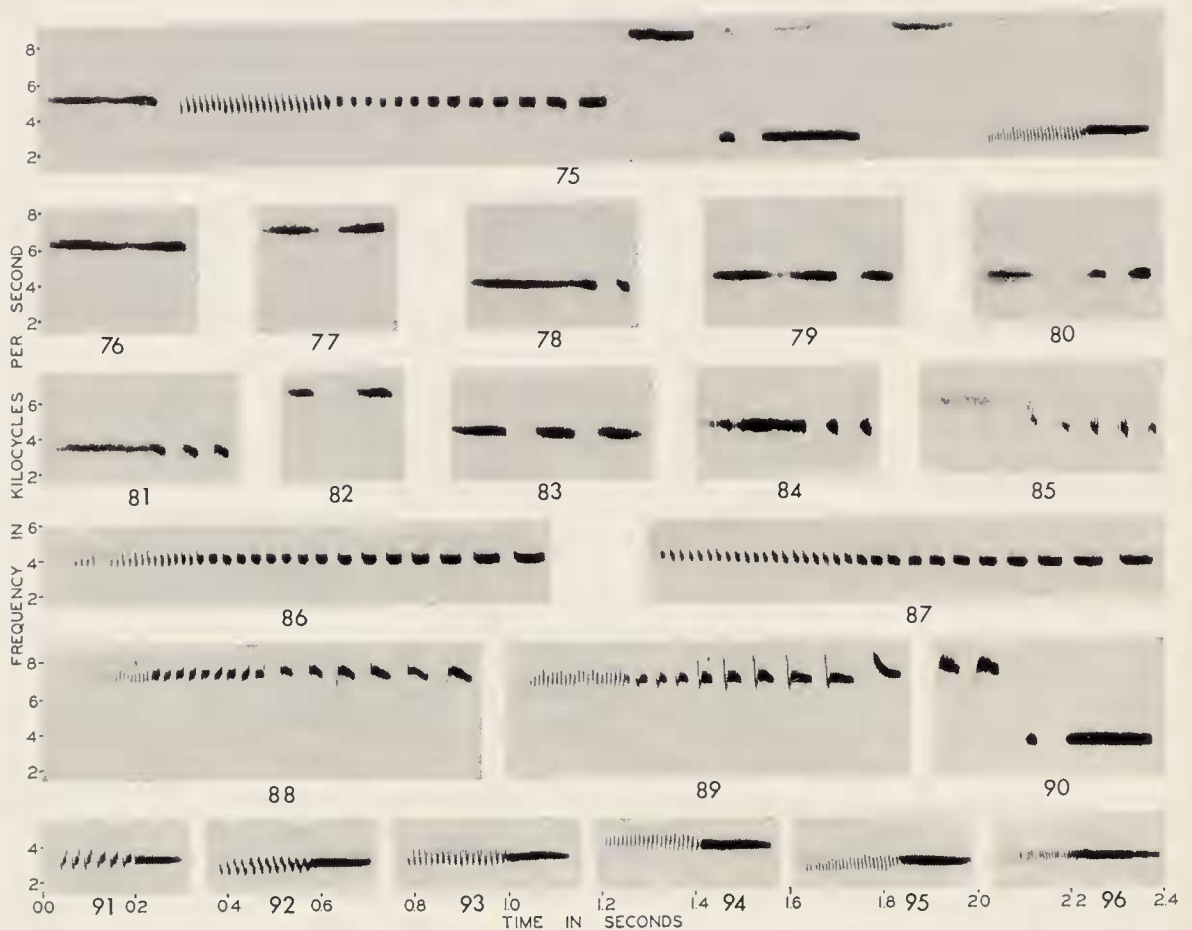
The Cassin's Sparrows recorded in Texas were presumably nesting birds; those recorded in Arizona were not. This species does not appear in the areas southeast of Tucson (where my recordings were made) until about mid-July, apparently after nesting farther east and then making a westward postnuptial flight. In this area of Arizona it sings quite a bit and acts as if it were defending territory, but apparently (Phillips et al., 1964) does not nest here.

A Cassin's Sparrow may sing from a perch (a fence, bush, or low tree) or in flight. When it sings in flight it sings while flying upward from a low perch at an angle of about 30°; near the end of the song the bird flies down to the ground or a low perch.

A typical Cassin's Sparrow song (Fig. 75) consists of a short introduction (*I*) of 1-5 notes, a prolonged phrase (*B*) that starts as a buzz and ends as a trill, a weak high-pitched note (*W*), a pair of low-pitched and relatively loud notes (*X*), another weak and high-pitched note (*Y*) similar to *W*, and a relatively loud and low-pitched final phrase (*Z*) that begins as a buzz and ends as a clear whistle: *I-B-W-X-Y-Z*. Descriptions of this species' song in the literature (e.g., Williams and LeSassier, 1968; Robbins et al., 1966) make no mention of the two high-pitched notes *W* and *Y*, and the graph by Robbins et al. (p. 316) does not show them, but nearly all the recorded songs studied contained them (*W* was lacking in a few songs, and a few songs ended before the *Y* note).

Each of the six parts of the song is steady in pitch or nearly so; there is occasionally a very slight drop in pitch through *I* and/or *B*, and the *W* and *Y* notes are usually slightly down-slurred (especially at the beginning). *I* and *B* are at the same pitch, or *B* may be a little lower than *I*. *W* and *Y* are at about the same pitch (or *Y* may be a little higher), and *X* and *Z* are about the same pitch. *W* and *Y* are the highest-pitched notes in the song, and *X* and *Z* are the lowest.

The songs of this species are subject to variation in the pitch and character of each of the six parts of the song. Some of these variations are apparent to the ear (in the field) and some are not; the different songs of this sparrow sound very much alike. The songs in two of the 26 recordings studied were of a single pattern, those in 19 recordings were of two patterns, and those in three recordings were of three patterns. When a bird sang songs of two or more patterns, it generally sang one to three songs of one pattern, then changed to another. Thirteen of the 263 songs studied (in eight recordings) were short, ending before the final *Z* phrase. The songs of one pattern (of



FIGS. 75-96. Graphs of Cassin's Sparrow songs. Fig. 75. A typical song: *I-B-W-X-Y-Z* (9746-2). Figs. 76-85. Variations of *I*: Fig. 76, *I*₁, 5571-2; Fig. 77, *I*₂, 5558-2; Fig. 78, *I*₃, 10266-2; Fig. 79, *I*₄, 5583-1; Fig. 80, *I*₅, 5561-3; Fig. 81, *I*₆, 9747-5; Fig. 82, *I*₇, 9755-3; Fig. 83, *I*₈, 5572-1; Fig. 84, *I*₉, 10672-6; Fig. 85, *I*₁₀, 10683-2. Figs. 86-89. Variations of *B*: Fig. 86, type *a*, 5625-2; Fig. 87, type *b*, 5583-1; Fig. 88, type *c*, 10280-9; Fig. 89, type *a* (the last note in this figure is a short *W*), 5558-2. Fig. 90. The middle of a song lacking *W*; the first two notes in the figure are the end of *B*, and the remaining two notes are *X*. Figs. 91-96. Variations of *Z*: Fig. 91, 9755-3; Fig. 92, 5571-1; Fig. 93, 5571-2; Fig. 94, 10265-7; Fig. 95, 9754-1; Fig. 96, 9755-1.

a Texas bird) ended in a partial or complete second *Z* phrase, and one song of another pattern of this same bird began with $2\frac{1}{2}$ *Z* phrases: *Z-Z-½Z-I-B-W-X-Y-Z* (the $\frac{1}{2}$ *Z* consisted of the buzzy part of the phrase only). A summary of the variations in the songs studied is given in Table 5.

The *I* phrase varied in the number, character, and pitch of the notes it contained; the pitch variation was from 3.0 to 3.1 KHz in the different series, and the notes were of the following types (indicated by subscript numbers in the figure captions): 1—A relatively long whistled note of even amplitude (Figs. 75-76); 2—A note similar to No. 1. but with the amplitude reduced in the middle and the note appearing more or less 2-parted (Fig. 77); 3—Two notes, the first similar to No. 1 and the second shorter (Fig. 78):

TABLE 5
CHARACTERISTICS OF CASSIN'S SPARROW SONGS

| Phrase | Character | | Texas Songs | Arizona Songs | All Songs |
|----------|---|----------|----------------|------------------|--------------|
| | | 1 | 5 | 12 | 17 |
| | | 2 | 8 | 1 | 9 |
| | | 3 | 1 | 2 | 3 |
| | | 4 | 5 | 0 | 5 |
| | Number of song series ¹ with I of type ² | 5 | 1 | 0 | 1 |
| | | 6 | 0 | 3 | 3 |
| | | 7 | 6 | 4 | 10 |
| | | 8 | 3 | 2 | 5 |
| | | 9 | 1 | 0 | 1 |
| | | 10 | 1 | 0 | 1 |
| <i>I</i> | Length (in seconds) | Range | 0.24-0.49 | 0.21-0.49 | 0.21-0.49 |
| | | Aver. | 0.319 | 0.298 | 0.310 |
| | Median pitch (KHz) | Range | 3.9-7.5 | 3.0-8.1 | 3.0-8.1 |
| | | Aver. | 5.45 | 5.49 | 5.47 |
| | No. of song series with <i>B</i> of type ² | <i>a</i> | 18 | 12 | 30 |
| | | <i>b</i> | 12 | 8 | 20 |
| | | <i>c</i> | 1 | 4 | 5 |
| | Median pitch (KHz) | Range | 3.6-7.1 | 3.0-7.7 | 3.0-7.7 |
| | | Aver. | 4.96 | 5.03 | 4.99 |
| <i>B</i> | Modulation rate at beginning of phrase | Range | 52-180 | 47-168 | 47-180 |
| | | Aver. | 100.7 | 98.7 | 99.8 |
| | Modulation rate at end of phrase | Range | 9-15 | 9-13 | 9-15 |
| | | Aver. | 11.0 | 11.1 | 11.1 |
| | Length (in seconds) | Range | 0.68-1.19 | 0.45-1.04 | 0.45-1.19 |
| | | Aver. | 0.914 | 0.870 | 0.895 |
| | No. of song series (with song complete) with <i>W</i> : | Short | 3 | 1 | 4 |
| | | Lacking | 0 | 3 | 3 |
| <i>W</i> | Pitch at beginning (KHz) | Range | 8.2-10.3 | 8.2-9.5 | 8.2-10.3 |
| | | Aver. | 8.70 | 8.64 | 8.67 |
| | Pitch at end (KHz) | Range | 7.1-8.6 | 7.5-9.0 | 7.1-9.0 |
| | | Aver. | 8.10 | 8.23 | 8.15 |
| | Length (in seconds) | Range | 0.07-0.29 | 0.08-0.22 | 0.07-0.29 |
| | | Aver. | 0.170 | 0.150 | 0.162 |

¹ The term "song series" refers to the songs in a given recording of a particular pattern; a song pattern in this species is one in which the different parts of the song are of a particular type and pitch.

² The different types of *I* and *B* phrases are explained in the accompanying text.

TABLE 5 (Continued)

| Phrase | Character | | Texas Songs | Arizona Songs | All Songs |
|--------------------------|--|-------|----------------|------------------|--------------|
| X | Pitch (KHz) | Range | 2.5-3.8 | 2.3-4.4 | 2.3-4.4 |
| | | Aver. | 3.13 | 3.07 | 3.10 |
| | Length (in seconds) | Range | 0.19-0.31 | 0.25-0.32 | 0.19-0.32 |
| | | Aver. | 0.273 | 0.283 | 0.278 |
| Y | Pitch at beginning (KHz) | Range | 8.4-9.0 | 8.1-9.3 | 8.1-9.3 |
| | | Aver. | 8.61 | 8.74 | 8.66 |
| | Pitch at end (KHz) | Range | 7.6-8.7 | 7.8-9.3 | 7.6-9.3 |
| | | Aver. | 8.28 | 8.46 | 8.35 |
| | Length (in seconds) | Range | 0.13-0.22 | 0.11-0.17 | 0.11-0.22 |
| | | Aver. | 0.161 | 0.145 | 0.154 |
| Z | Modulation rate in first part of phrase | Range | 44-195 | 39-170 | 39-195 |
| | | Aver. | 81.4 | 97.3 | 86.4 |
| | Pitch of last part of phrase (KHz) | Range | 2.6-3.8 | 2.7-4.4 | 2.6-4.4 |
| | | Aver. | 3.26 | 3.25 | 3.26 |
| | Length (in seconds) | Range | 0.27-0.40 | 0.27-0.39 | 0.27-0.40 |
| | | Aver. | 0.348 | 0.335 | 0.342 |
| Song Length (sec.) | Complete normal songs | Range | 2.00-2.83 | 1.55-2.72 | 1.55-2.83 |
| | | Aver. | 2.498 | 2.316 | 2.418 |
| | All songs | Range | 1.5-3.67 | 1.44-2.72 | 1.44-3.67 |
| | | Aver. | 2.811 | 2.247 | 2.383 |

4—Two notes, as in No. 3, but the first like No. 2 (Fig. 79); 5—Two notes, similar to No. 3, but slightly buzzy (Fig. 80); 6—Similar to No. 5 but with two short buzzy notes at the end (Fig. 81); 7—Two short whistled notes, each less than half as long as No. 1 (Fig. 82); 8—Three notes like those in No. 7 (Fig. 83); 9—Three whistled notes, the last two short (Fig. 84); 10—A buzzy note plus four short notes at a lower pitch (Fig. 85).

The *B* phrase was the same pitch as *I* or slightly (1-2 musical intervals) lower. It varied in the different series in pitch (similar to the pitch variations in *I*), the way the modulation rate decreased through the phrase, and the modulation rate at the beginning of the phrase. Based on the way the modulation rate decreased through the phrase, the *B* phrases were of three types: *a*—With the decrease relatively abrupt near the middle of the phrase (Figs. 75, 86, 89); *b*—With the decrease more gradual (Fig. 87); *c*—With

the decrease in two relatively abrupt steps, the phrase appearing more or less three-parted (Fig. 88).

The modulation rate at the beginning of the *B* phrase varied in different series from 47 to 180 per second. The elements in the buzzy part of this phrase were sometimes (Figs. 75, 87) slightly down-slurred; in other cases they were more abruptly down-slurred (Fig. 88), or with both down- and up-slurred elements (Figs. 86, 89). The notes at the end of the *B* phrase were generally clear whistles of uniform pitch (Figs. 75, 86, 87), but in a few cases they began with an abrupt down-slur (Fig. 89).

The *W* and *Y* notes were high-pitched, and generally somewhat down-slurred (especially at the beginning). The *W* note was 0.13–0.29 sec. in length in most songs, but in songs with *I* and *B* very high pitched it was shorter (0.07–0.08 sec.) and distinctly down-slurred (Fig. 89). The *W* note was lacking in a few song patterns (Table 5 and Fig. 90).

The *X* phrase consisted of two clear and relatively loud notes, a short one and a long one (Fig. 75). It was uniform in pitch, but in different song series varied in pitch from 2.5 to 4.4 KHz; it was generally the lowest-pitched phrase in the song. In one song of one recording (a Texas bird) this phrase began with two short notes.

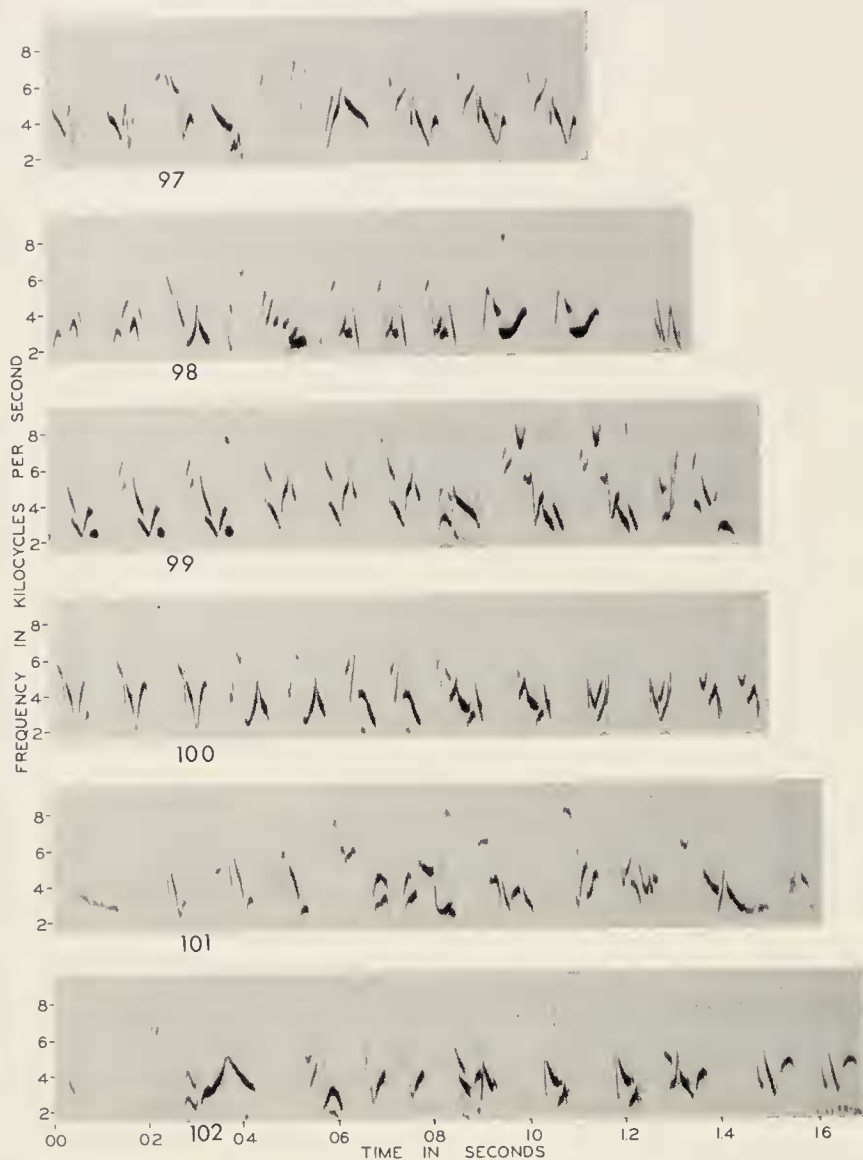
The *Z* phrase began with a buzz and ended in a clear note; the buzz had a relatively uniform modulation rate throughout, and the change from buzz to clear note was quite abrupt (Figs. 75, 91–96). The pitch of the final part of this phrase was the same as that of *X*, or a little higher. The modulation rate of the buzzy part of this phrase varied in different song series from 39 to 195 per second.

Forty-eight different song patterns were found in the recordings studied, 25 in the Texas birds and 23 in the Arizona birds; only one instance was found of a given pattern being sung by two different birds (about ½ mile apart, in Texas).

Most of the differences found between the songs of the Texas and Arizona birds (Table 5) were relatively minor; the more significant differences were: (a) a long clear note in the *I* phrase was more often 2-parted in Texas songs; (b) a *B* phrase of type *c* (more or less 3-parted) was more common in Arizona songs than in Texas songs; (c) the only complete songs lacking the *W* note were sung by Arizona birds; and (d) the modulation rate in the buzzy part of the *Z* phrase averaged higher in Arizona songs than in Texas songs.

RUFOUS-CROWNED SPARROW

The songs of this sparrow have a chippery and somewhat canary-like quality, and resemble those of a House Wren (*Troglodytes aedon*) or an



FIGS. 97-102. Graphs of Rufous-crowned Sparrow songs. Fig. 97, 10253-3; Fig. 98, 7198-1; Fig. 99, 9749-2; Fig. 100, 7197-1; Fig. 101, 9616-2; Fig. 102, 7065-3.

Indigo Bunting (*Passerina cyanea*); they are higher pitched than those of a House Wren, and faster than those of an Indigo Bunting. The average frequency range found was 1.8-7.3 KHz, with extremes of 1.2 and 8.5 KHz. An account of the song of this species is given by Phillips and Cogswell (1968), and a sonagram of a song (weak, and difficult to make out) is given by Robbins et al. (1966:316).

Rufous-crowned Sparrow songs consist of a series of phrases, most of which are uttered two or three times in succession: 1-3 phrases of one type, 1-3 of another type, and so on; rarely, a phrase may be uttered four or five times in succession. The phrase rates in the songs studied varied from 3.3 to 14.7 per second (average, 7.6 per second). Individual songs contained 9-16 (average, 12.6) phrases, of 6-10 (average, 6.4) types.

Individual phrases are usually rather complex, consisting of several slurred elements, sometimes with successive slurs overlapping (Figs. 97–102). Most of this slurring is quite abrupt—over an octave or so in 0.02 sec. or less.

The different songs in some recordings were alike in the number of phrase types present and in their sequence, but differed in the number of certain phrases; in other recordings there was variation in the particular phrase types present and/or in their sequence. Three of the six birds studied had a repertoire of six phrase types; the others had repertoires of seven to sixteen phrase types. It is probable that most birds have a repertoire of a dozen or more types of phrases, but rarely use more than six or eight of them in a given song. Different renderings of a given phrase type by a particular bird (in the same or different songs) often differed slightly. The recordings studied contained no instances of different birds having identical phrases in their songs, but there were instances of very similar phrases in the songs of different birds.

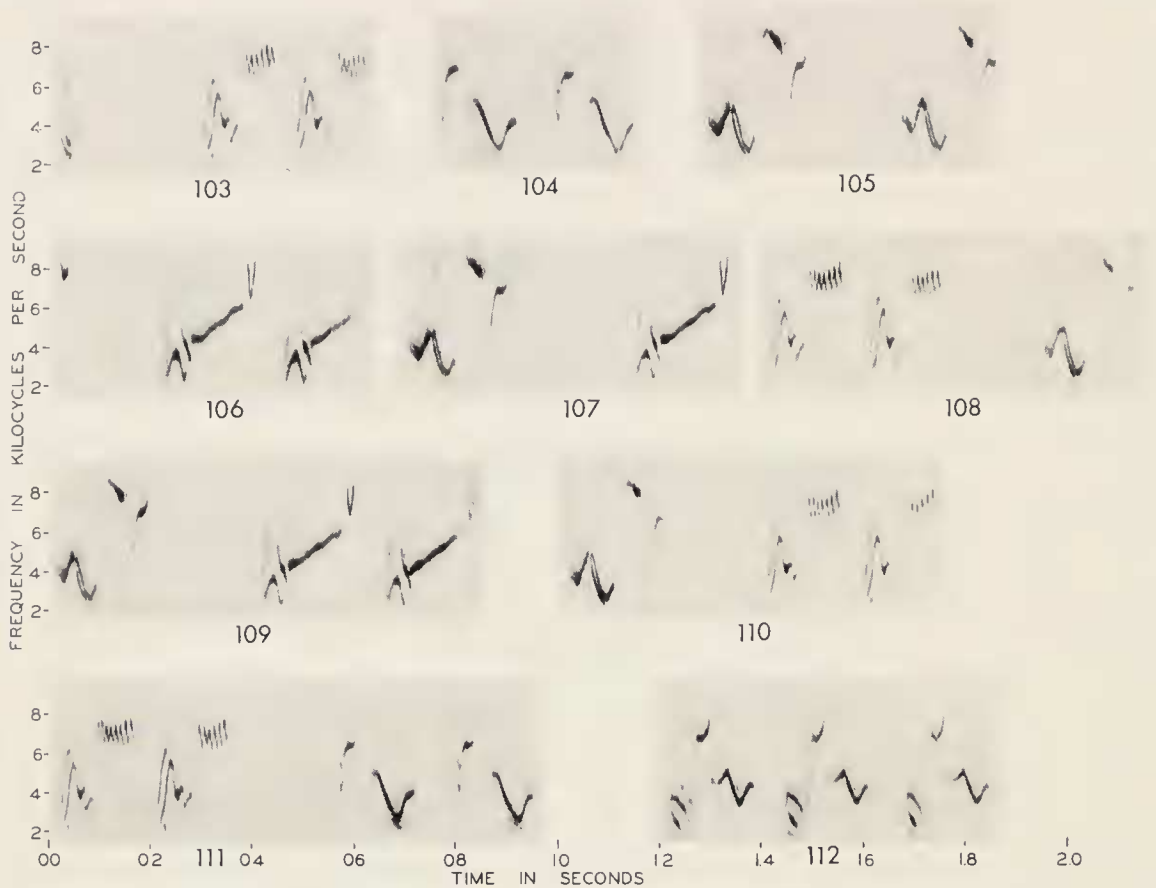
FIVE-STRIPED SPARROW

The only recording of this species studied (OSU Recording No. 10185) was made at a roadside picnic area on Arizona Route 82 about 3½ miles southwest of Patagonia, 28 June 1969. This appears to be only the second occurrence of this species in the United States; the first was a specimen collected in Madera Canyon (about 20 miles north of the area where my recording was made), 18 June 1957 (Phillips, Marshall, and Monson, 1964).

The songs of this species are relatively short, consisting of 1–4 phrases of one or two types. There were five types of phrases in the songs studied; these may be designated by letters, *A–E* (Figs. 103–110). There were two types of calls in the recording, a short and very high pitched *pip* (Fig. 106), and a lower-pitched *chuck* (Fig. 103); these were uttered more or less irregularly between songs, sometimes just before a song (and thus appearing to be the first note of the song, as in Figs. 103 and 106).

The 113 songs in the recording studied were of the following types: *A-A*—25 songs; *B-B*—12 songs (Fig. 104); *C*—12 songs; *C-C*—11 songs (Fig. 105); *D*—4 songs; *D-D*—27 songs; *E-E*—3 songs; *E-E-E*—10 songs (Fig. 112); *A-A-C*—1 song (Fig. 103); *A-A-B-B*—1 song (Fig. 111); *C-A-A*—1 song (Fig. 110); *C-D*—4 songs; *C-D-D*—2 songs (Fig. 109).

Most (82 of the 113) of the songs contained two phrases; 16 contained only one phrase, 14 contained three phrases, and one contained four phrases. The bird sang songs containing two or three different phrases for a while, then changed to songs of other phrases. Songs containing different phrases were sung more or less alternately (*A-A*, *B-B*, *A-A*, *B-B*, etc.).



FIGS. 103-112. Graphs of Five-striped Sparrow songs (from Recording No. 10185). Fig. 103, *chuck-A-A*, song 49; Fig. 104, *B-B*, song 2; Fig. 105, *C-C*, song 67; Fig. 106, *pip-D-D*, song 50; Fig. 107, *C-D*, song 73; Fig. 108, *A-A-C*, song 29; Fig. 109, *C-D-D*, song 75; Fig. 110, *C-A-A*, song 35; Fig. 111, *A-A-B-B*, song 31; Fig. 112, *E-E-E*, song 94.

The phrases were uttered at rates of 2.8 to 5.6 per second. The two-phrase songs were generally 0.3–0.4 second in length, and the three-phrase songs 0.6–0.7 second in length.

DISCUSSION

Some songs of the Rufous-winged and Bachman's Sparrows are very much alike, and the songs of Botteri's Sparrow are similar to those of the Bachman's and Rufous-winged Sparrows in that they contain a trill, but the songs of the other three species are different from one another and from the aforementioned three species.

Table 6 presents a comparison of certain features of the songs of these six species. In three species (Bachman's, Rufous-winged, and Five-striped Sparrows) each bird may have a relatively large song repertoire—13 or more different song patterns; the repertoires of a given individual of the other three species appear to be very limited. The greatest variation from individual to individual in the species appears to be in the Bachman's Sparrow—where

TABLE 6
SUMMARY OF SOME FEATURES OF *AIMOPHILA* SONGS

| Species | Total Song Patterns in the Recordings Studied | Maximum Number of Song Patterns per Bird | No. of Songs in a Series ¹ | Identical Song Patterns by Different Birds | Average Singing Rate (songs per minute) ² |
|------------------------|---|--|---------------------------------------|--|--|
| Bachman's Sparrow | 244 ³ | 39 | 1-4 | rare | 5.7 ⁴ |
| Rufous-winged Sparrow | 33 | 19 | many | common | 10.5 |
| Botteri's Sparrow | 6 | 2 | many | none found | 4.8 |
| Cassin's Sparrow | 42 | 3 | 1-3 | rare | 4.2 ⁵ |
| Rufous-crowned Sparrow | 6 | 1 | many | none found | 6.4 |
| Five-striped Sparrow | 13 | 13 | 1-2 | - | 15.1 |

¹ Songs of a given pattern, before changing to another pattern.

² Based on all the inter-song intervals measured.

³ Excluding the imitations of a Field Sparrow (11 songs, of five patterns, by one bird).

⁴ 6.2 in Ohio birds, 4.4 in Florida birds.

⁵ 4.1 in Texas birds, 4.5 in Arizona birds.

each bird may have a relatively large repertoire, and the repertoires of different individuals are generally different. The sample of Rufous-crowned Sparrow songs was small, but there is probably a great deal of variation from bird to bird in this species. Cassin's and Botteri's Sparrows exhibit a large amount of intraspecific variation in song, but the differences between different song patterns in these species are relatively slight. The material of the Rufous-winged Sparrow studied indicates that different individuals in this species frequently sing songs of the same patterns. There is probably a large amount of intraspecific variation in the songs of the Five-striped Sparrow.

There are differences in the singing behavior of these six species. Cassin's Sparrow appears to be the only one that frequently sings in flight. The singing rate is relatively high in two species (averaging 15.1 songs per minute in the Five-striped Sparrow, and 10.5 per minute in the Rufous-winged), and distinctly lower (4.2-6.4 songs per minute) in the other four species. The Rufous-winged, Botteri's and (apparently) the Rufous-crowned Sparrows sing songs of a given pattern for some little time before changing to another

song pattern; the Bachman's, Cassin's, and Five-striped Sparrows generally sing only a few (one to four) songs of one pattern before changing to another pattern.

On the basis of the character of their song and their singing behavior, and on the basis of appearance, four of these species appear to be very closely related—Bachman's, Botteri's, Cassin's, and Rufous-winged Sparrows; the other two species differ in both appearance and song. In its singing behavior the Rufous-crowned Sparrow is probably closer to a *Melospiza* (e.g., Lincoln's Sparrow, *M. lincolni*) than to the other species of *Aimophila*. The Five-striped Sparrow looks a little like a Black-throated Sparrow (*Amphispiza bilineata*), but its songs are quite different.

SUMMARY

Descriptions are given of the songs and singing behavior of the six species of sparrows in the genus *Aimophila* occurring in the United States (Bachman's, Rufous-winged, Botteri's, Cassin's, Rufous-crowned, and Five-striped), based on a study of 66 recordings (1,769 songs). The songs of Bachman's, Rufous-winged, and Botteri's Sparrows are similar in some respects, but there is little similarity between the songs of these three species and those of the other three species. The six species differ in the size of individual repertoires, the way the repertoires are used, the occurrence of identical songs by different individuals, and the singing rate.

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The Society of Systematic Zoology and the International Association for Plant Taxonomy have joined forces to develop this first opportunity for botanical/zoological interaction at an international level. The Congress will be held on the campus of The University of Colorado at Boulder, 4-11 August 1973. The program plans include interdisciplinary symposia and contributed paper sessions. The botanists will not convene a nomenclatural section but a zoological one on this subject is anticipated. All suggestions for program and other activities will be gratefully received. Further information can be obtained from the Secretary of the Steering Committee: Dr. James L. Reveal, Department of Botany, University of Maryland, College Park, Maryland 20740.